Landsat 7 Processing System (LPS)

System Design Review/ Software Specification Review

March 9, 1995

Agenda

• Introduction	J. Henegar
• System Design	R. Schweiss
• Software Specification	J. Hosler D. Sames
• Conclusion	J. Henegar

Agenda

- **Introduction**
  - **Purpose and Scope**
  - **SRR Follow-up**
  - **Requirements Overview**
- **System Design**
- **Software Specification**
- **Conclusion**

Purpose and Scope

- **Purpose**
  - Present synopsis of LPS System Design and Software Requirements Analysis efforts
  - Obtain CCB approval of the LPS System Design and Software Requirements Analysis
    - » Insure that System Design will meet requirements allocated to the LPS, within the cost baseline, at an acceptable risk
    - » Insure that the Software Requirements meet the requirements allocated to software during the system design phase

Purpose and Scope (con't)

- **Scope**
  - **System Design Encompasses:**
    - » Allocating requirements to functions
    - » Partitioning functions to subsystems
    - » Defining internal and external interfaces
    - » Developing system architecture
    - » Analyzing system operations
    - » Performing studies to guide design, mitigate risk
  - **Software Requirements Analysis Encompasses:**
    - » Defining detailed software requirements
    - » Defining detailed inter-subsystem interfaces, refining external interfaces
    - » Allocating and defining detailed Software Configuration Items(SWCI)
    - » Defining detailed user-system interface requirements and operations scenarios
    - » Creating an initial system performance model

- **System Design Background**
  - **Informal System Design Review was conducted December 15, 1994**
    - **Ground System Manager and Interfacing elements were represented**
    - **Established internal baseline for the System Design**
  - **Comments received from review were addressed and incorporated into the internal baseline as appropriate**

Documentation

- **Following Documentation is available on-line for review**
  - **LPS System Design Specification**
  - **LPS Software Requirements Specification**
  - **LPS-LGS Interface Control Documentation**

- **If on-line access is not available please contact one of the presenters**

- **Please submit RIDS to: Phil Province (bldg 23, RM C429, 286-7731) no later than March 23, 1995**

LPS SRR Follow-up

- **31 RIDS received as result of the LPS SRR conducted October, 1994**
  - **RIDS without cost impacts were addressed and incorporated into signature copies of the F&PS and the Operations Concept as appropriate**
  - **RIDS with cost impacts were provided to the Ground System Manager.**

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Requirement Issues/Status

- **Insufficient disk storage allocated in the LPS baseline to support the 8 hour latency requirement.**
  - **LPS Disk storage will be upgraded to appropriate amount, but purchase will be delayed until as late as possible to minimize cost impacts**
- **I and Q channels are processed on two independent LPS strings. Output files need to be consolidated into a single user product**
  - **Working with ECS personnel to determine appropriate and cost-effective place to allocate requirement**
- **LPS output granularity is on a subinterval basis which impacts the ECS**
  - **Working with ECS personnel to determine appropriate and cost-effective place to allocate requirement**

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Requirement Issues/Status

- **Addition of capability for viewing image in the LPS (moving window display)**
  - **Pursuing options to develop independent of the baseline. Options will be dependent on implementation productivity and/or in-house personnel availability. If funding comes available will add to the baseline.**
- **Addition of capability for manual cloud cover assessment**
  - **Automated Cloud Cover algorithm is being worked for improvement by LSQAT and LPS team members.**
- **Addition of capability for real-time return link Q&A**
  - **Post-pass return link quality and accounting is sufficient for this project.**

System Requirement Overview

- Receive raw wideband data from the LGS and record raw data for 4 wideband data inputs simultaneously on a contact basis
- Perform CCSDS AOS Grade-3 service and BCH Error Detection and Correction on all received wideband data
- Generate the following on a subinterval basis
  - Level 0R Data Files
  - Browse data files
  - Metadata files
- Perform automatic cloud cover assessment
- Provide WRS Scene Identification

System Requirement Overview (con't)

- Generate post-pass return link quality and accounting on a contact period basis

- Generate level 0R quality and accounting on a subinterval basis

- Coordinate the transfer of all Level 0R related files to the Land Processes Distributed Active Archive Center (LP DAAC)

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Operational Requirements

- **Support Operations 24 hours per day, 7 days per week, on a continuous basis for a minimum mission life of 5 years.**
- **Capability to Configure, Monitor, and Control LPS operations**
- **Provide capability to generate and report error messages**
- **Support upgrades, preventative maintenance, and operator training on a non-interruptive basis**
- **Provide override capabilities for automated functions**

Performance Requirements

- Receive and process equivalent of 250 scenes per day
- Reprocess a maximum of 10% of the daily input volume
- Receive and capture data at 75Mbps per input stream (4 simultaneously) from the LGS
- Process wideband data within 16 hours of receipt at LPS
- Process received wideband data at a daily average aggregate rate of 12 megabits per second
- Process data at >= 7.5 Mbps per input stream
- Store raw data on removable media for 60 days

LPS Output Files

- Level 0R data files
  - » Instrument data files - Each file contains image data from single band in a single subinterval. Data nominally aligned using fixed and predetermined integer values
  - » Calibration files - One file created per subinterval. Contains Calibration data received on a major frame basis.
  - » Mirror Scan Correction files - One file created per subinterval. Contains scan error and scan direction data
  - » PCD (Payload Correction Data) files - One file created per subinterval. Contains Payload Correction Data for the subinterval

LPS Output Files (con't)

- Metadata file
  - One file created per subinterval. Contains data quality and accounting information, cloud cover assessment, and scene identification information for the subinterval
- Browse Image Files
  - One monochrome (image from a single band) file and one multiband (image from three predefine bands) file created per subinterval. Contains reduced size scenes of the full size scene data contained in the Level 0R instrument data files.

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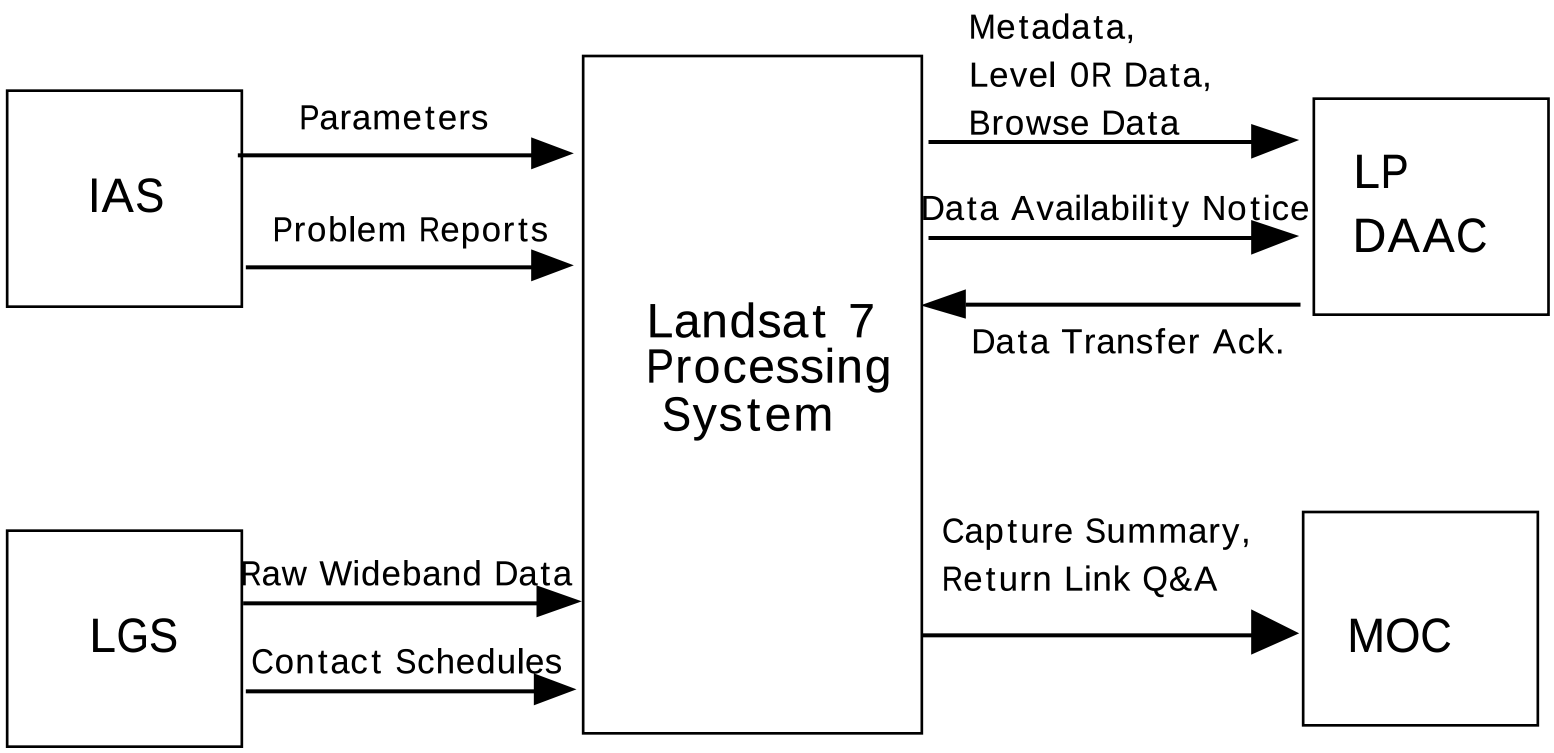
LPS Context Diagram



LPS Context Diagram

- LGS
  - » Coordinate with LGS to capture wideband data on contact basis
  - » Receive wideband data at 75 Mbps on four physical channels
- MOC
  - » Provide raw capture summary
  - » Provide non-nominal return link quality statistics
- IAS
  - » Receive Parameters for sensor alignment and scene identification
  - » Receive anomalous image quality statistics
- LP DAAC
  - » Notify LP DAAC of data availability
  - » Receive transfer status from the LP DAAC

Agenda

- Introduction
- **System Design**
  - Methodology
  - Trade Studies
  - The LPS Architecture
  - Operational Scenarios
- Software Specification
- Conclusion

Methodology

- Structured System Design Methodology (SSDM)
- Basis of LPS System Design

Methodology

- The LPS system design is being developed using the SEAS System Design Methodology (SSDM) tailored to suit the LPS project environment.
- The LPS system design has been accomplished by performing the following major activities:
  - Analysis of the Landsat 7 System Specification and Operations Concepts documents to identify system design drivers, constraints and assumptions
  - Functional decomposition of LPS system requirements via structured analysis to
    - » Identify hardware and software components.
    - » Define the scope of the system, subsystems, and interfaces
  - Development and analysis of:
    - » Alternative architectures and hardware configurations to facilitate the selection of an architecture that optimally meets system requirements
    - » Software architecture that conforms to the selected hardware configuration, and maximizes the use of COTS items and RENAISSANCE Building Blocks in its design.
- Generation of the LPS System Design Specification and Interface Data Descriptions (IDD).
- Identification of LPS issues which may impact the LPS system design.

Methodology (cont.)

Basis of LPS System Design

- Trade Studies
  - Raw Data Capture
  - Front-end
  - Compute processor
  - LPS Console*
  - Back-End
  - Distributed vs Centralized*

- Prototype Studies
  - Raw Data Capture
  - CCSDS Processing
  - BCH Error Detection and Correction
  - Band deinterleave
  - ETM+ major Frame Processing
  - Cloud Cover Assessment
  - Browse Generation

- Technical Studies
  - RMA Analysis
  - Workload and Traffic (Sizing) Analysis
  - Performance (Response/Latency) Analysis*
  - Operations
  - WRS Scene Identification*
  - Sun Azimuth and Elevation Angle Determination*
  - HDF Study*
  - Re-use Analysis
  - LPS Testability Analysis*

* Not presented see System Design Specification Appendix C

Trade Studies

- Raw Data Capture
- Front-end
- Compute processor
- LPS Console*
- Back-End
- Distributed vs. Centralized*

* Not presented see System Design Specification Appendix C

The following criteria were used in the Trade Study evaluation process:

- Cost
- Maintenance
- Availability
- Reliability
- Support
- Maturity
- Performance
- Compatibility
- Flexibility

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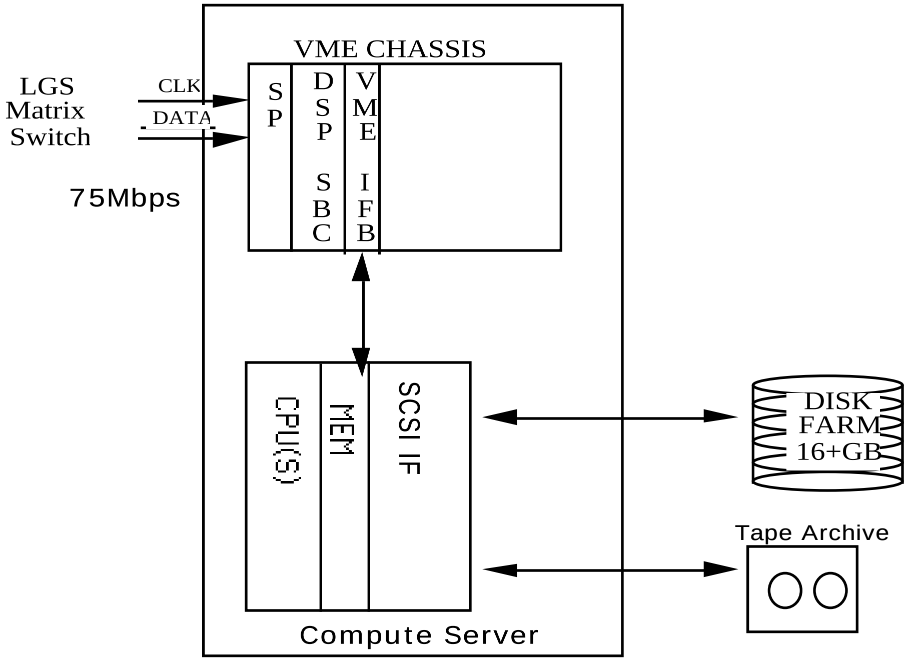
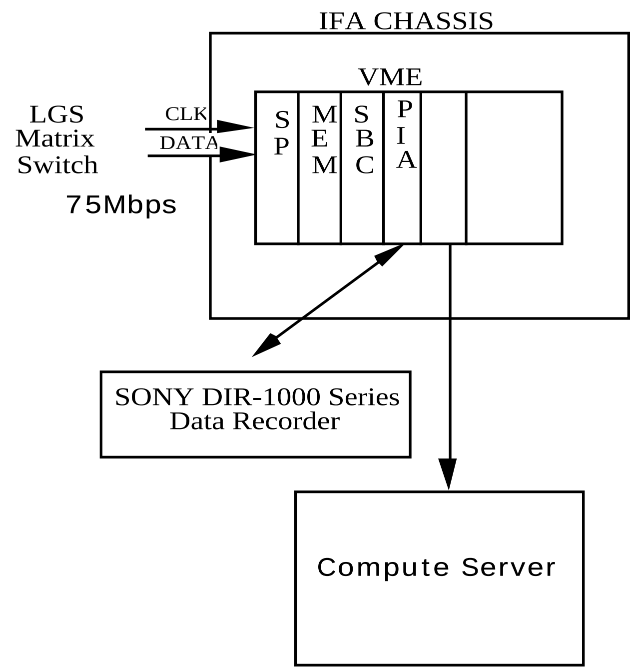
Raw Data Capture Trade Study



Capture to Disk



Capture to Tape

<u>Option 1</u>

• Data is received by the Serial-Parellel card and transferred to the Compute Server via the DSP card for recording onto disk and post contact recording to tape.

<u>Option 2</u>

• Data is received via the Serial to Parallel Converter (SP), Peripheral Interface Adapter (PIA), and DSP Cards and forwarded to the Sony DIR-1000 for recording onto Tape in Real time.

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Raw Data Capture Trade Study (cont.)

Advantages	Disadvantages
Option 1 Capture to Disk	Option 1 Capture to Disk
• Permits simultaneous record and playback • Data available on Demand • Maximizes throughput • Permits Random access to data • Disk Array has high fault tolerance	• Requires development and testing • Post contact tape production
Option 2 Capture to Tape	Option 2 Capture to Tape
• Commerciallyavailable off the shelf • Data is on removable media immediately	• Single function either record or playback • Sequential access • Constant playback speed • Expensive • Relatively Low MTBF • Tape Drive requires spin up lead time • Filemarks must be used to locate data on tape

Selection: Option 1, Option 1 Capture to Disk was selected

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Front End Trade Study

OPTION 1 - HARDWARE REUSE

OPTION 2 - ASIC HARDWARE (< 20 Mbit/sec)

OPTION 3 - ASIC HARDWARE (<150 Mbit/sec)

OPTION 4 - MODIFIED HIGH DENSITY TAPE INTERFACE

OPTION 5 - HIGH DENSITY TAPE SUBSYSTEM

OPTION 6 - LPS SELECTED ARCHITECTURE

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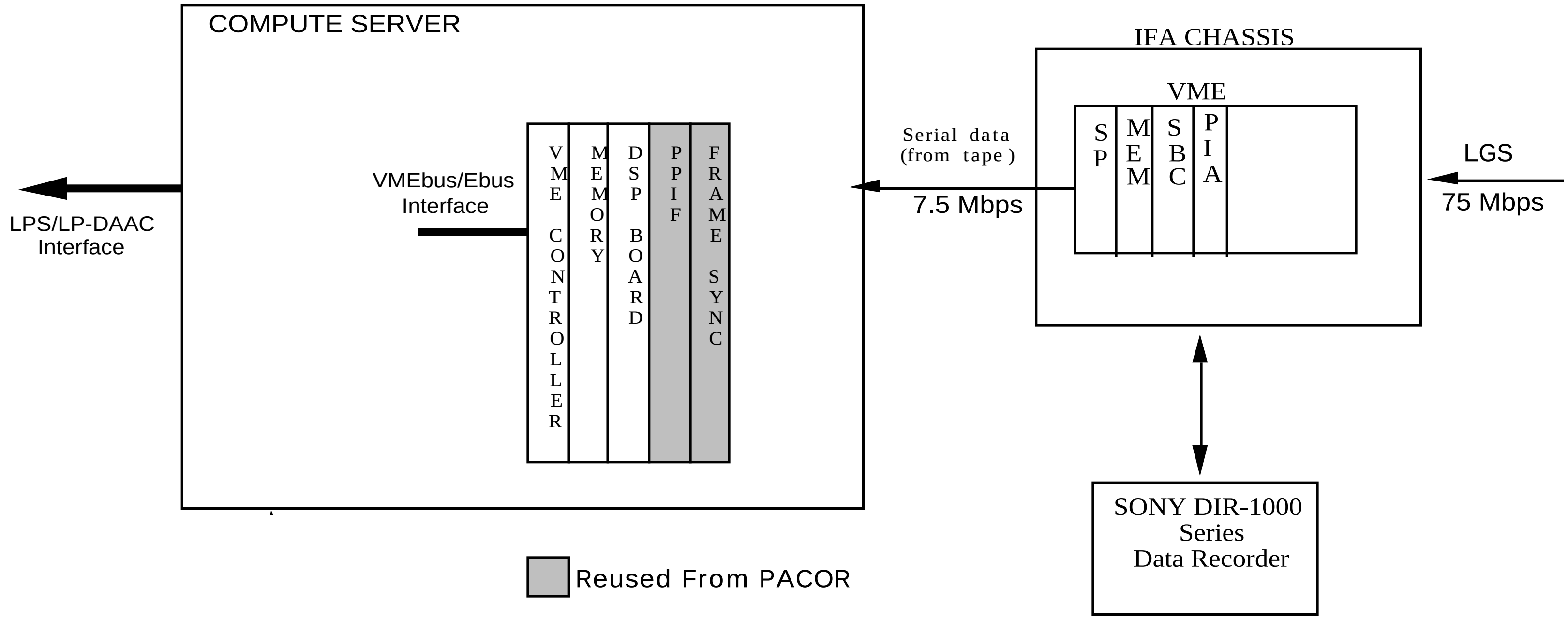
Front End Trade Study (cont.)

OPTION 1 - HARDWARE REUSE (BASELINE CONFIGURATION)



• Utilizes Application Specific Integrated Circuit (ASIC) technology developed by NASA.

• Landsat 7 ETM+ wideband data is captured onto a high speed (75 Mbits/sec) high density tape during satellite contact periods.

• The data is subsequently replayed to the frame sync detector board at 7.5Mbps. Data is then buffered by the Packet Processor Interface board (PPIF) and forwarded to the DSP board which performs header Reed Solomon and frame BCH bit error correction. The data is then forwarded to the Compute Server for Level 0R processing and data dissemination.

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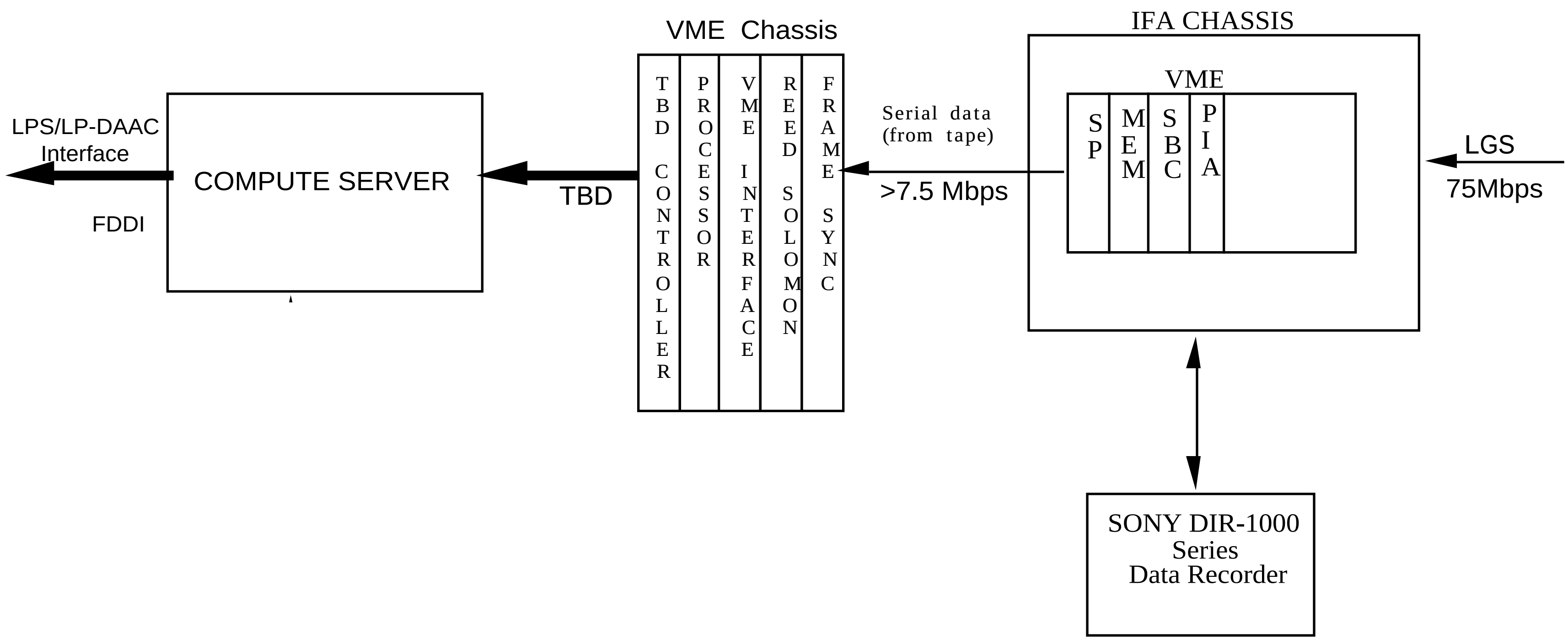
Front End Trade Study (cont.)

OPTION 2 - ASIC HARDWARE (< 20 Mbit/sec)



• Utilizes Application Specific Integrated Circuit (ASIC) technology developed by NASA.

• Landsat 7 ETM+ wideband data is captured onto a high speed (75 Mbits/sec) high density tape during satellite contact periods. Subsequent replay of the data is greater than or equal to 7.5 Mbits/sec. The serial data is processed by the frame synchronizer and Reed Solomon decoder prior to transfer to the compute server via a TBD LAN. The data is then forwarded to the Compute Server for Level 0R processing and data dissemination.

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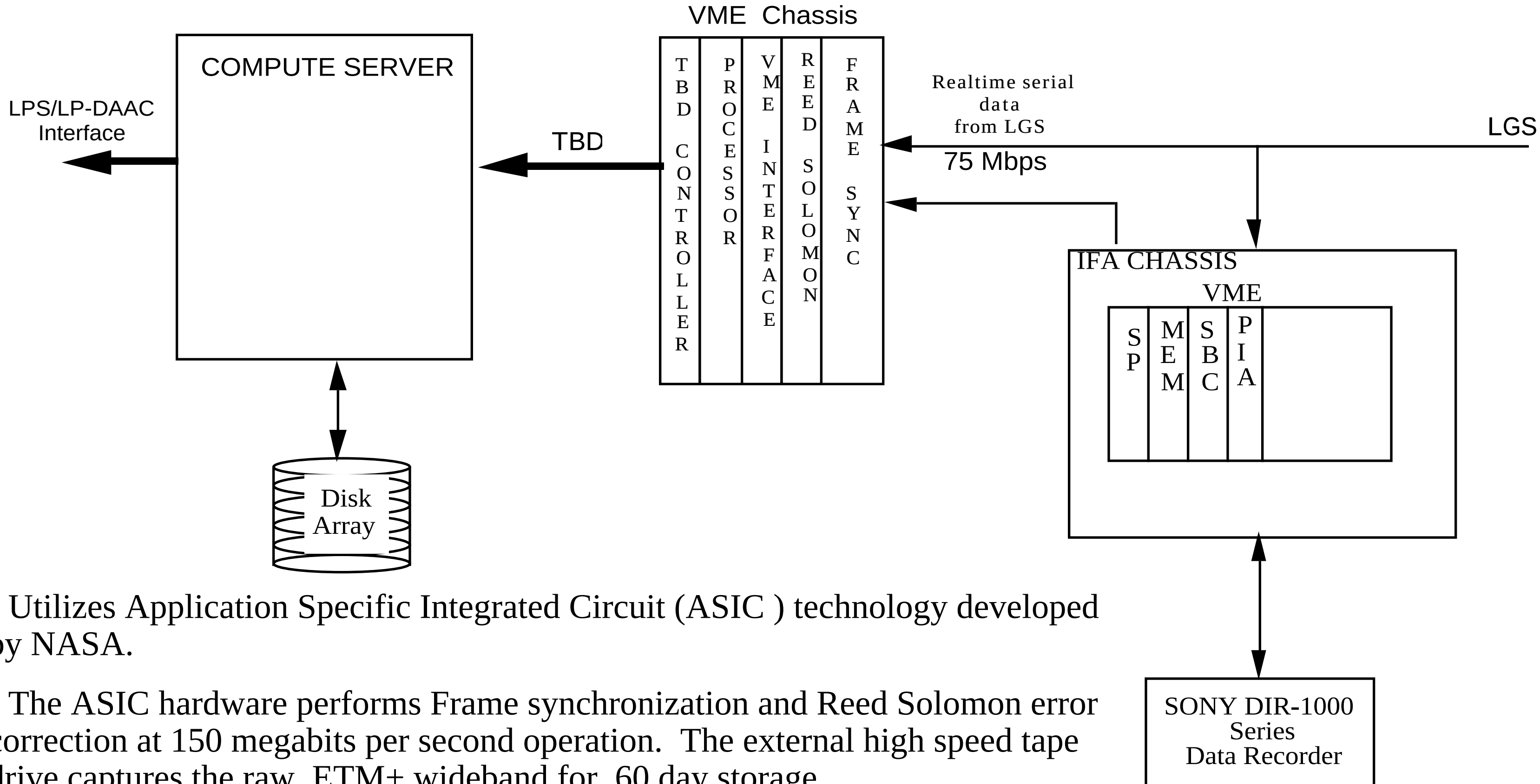
Front End Trade Study (cont.)

<u>OPTION 3 - ASIC HARDWARE (<150 Mbit/sec)</u>

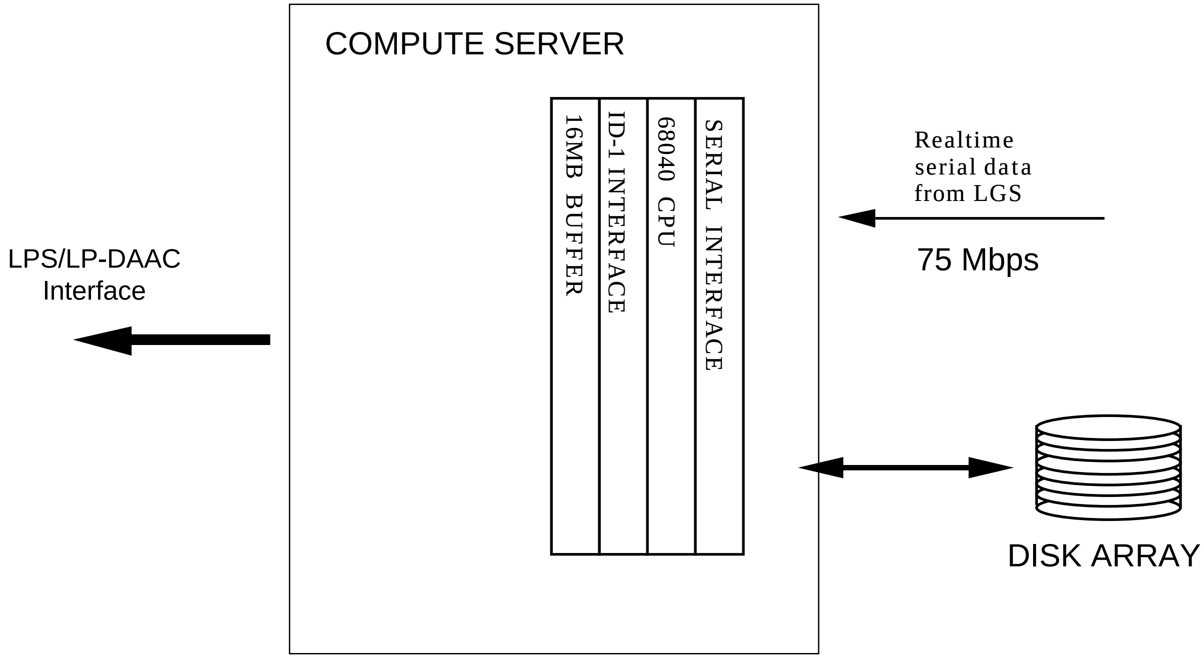


• Utilizes Application Specific Integrated Circuit (ASIC) technology developed by NASA.

• The ASIC hardware performs Frame synchronization and Reed Solomon error correction at 150 megabits per second operation. The external high speed tape drive captures the raw ETM+ wideband for 60 day storage.

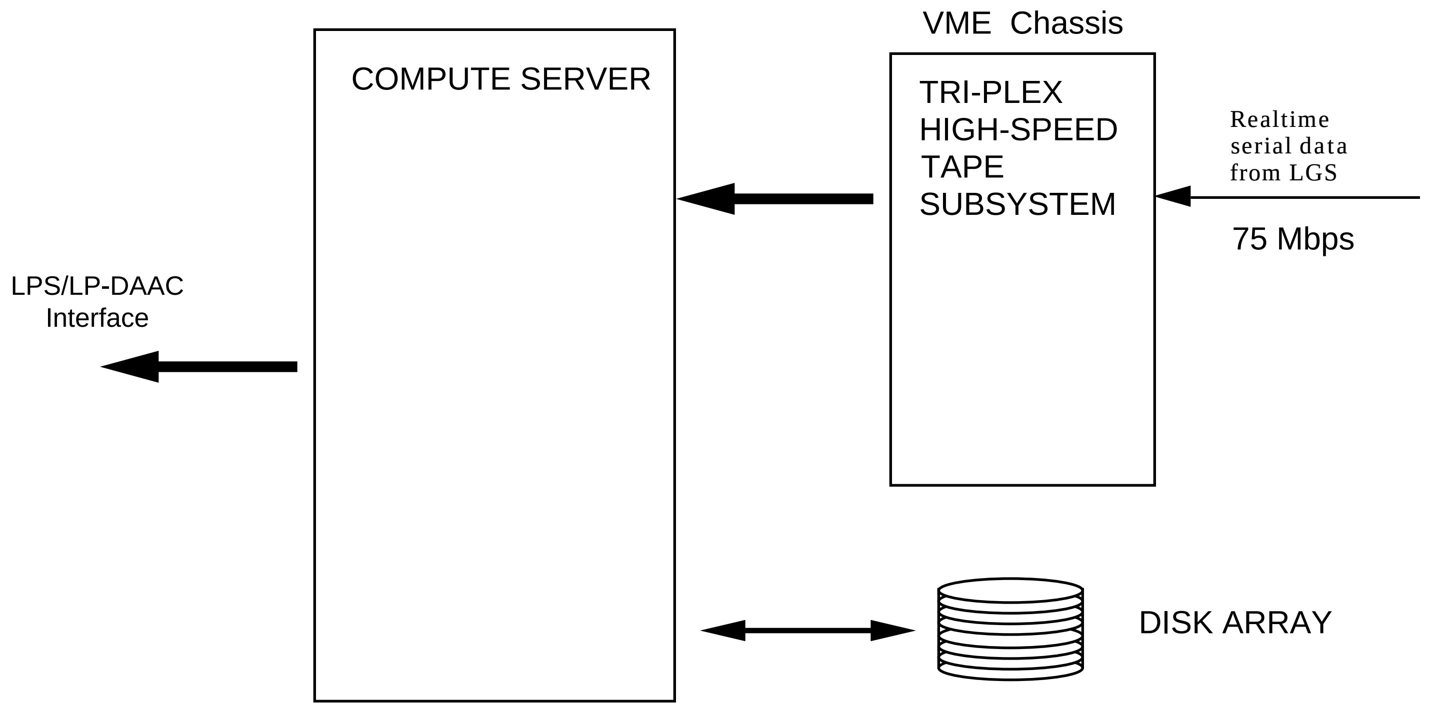
• The real-timeLandsat 7 ETM+ wideband data (75 Mbits/sec) is processed by the frame sync and Reed Solomon, and BCH hardware during spacecraft contact and transferred to a disk array via a TBD network and a compute server for storage.

OPTION 4 - MODIFIED HIGH DENSITY TAPE INTERFACE



- Utilizes four VME circuit boards available as COTS hardware from EDAC Systems Inc.
- The board set consists of a Serial Interface board, a Motorola 68040 SBC, an ID-1 Interface Board, and a 16 MByte Memory Card.
- These COTS boards are designed by the manufacturer to provide an interface and control subsystem to a commercially available high-speed, high-density data acquisition tape recorder such as the Sony DIR-1000.
- The received data is transferred to the data capture disk array for subsequent post contact processing and storage.

OPTION 5 - HIGH DENSITY TAPE SUBSYSTEM



- Utilizes COTS hardware from TRI-PLEX Systems Inc.
- This subsystem is provided in a stand-alone VME chassis which communicates to the compute server via a communication link.
- The real-time data is input directly to the controller and transferred to the data capture disk array for subsequent post contact processing and storage.

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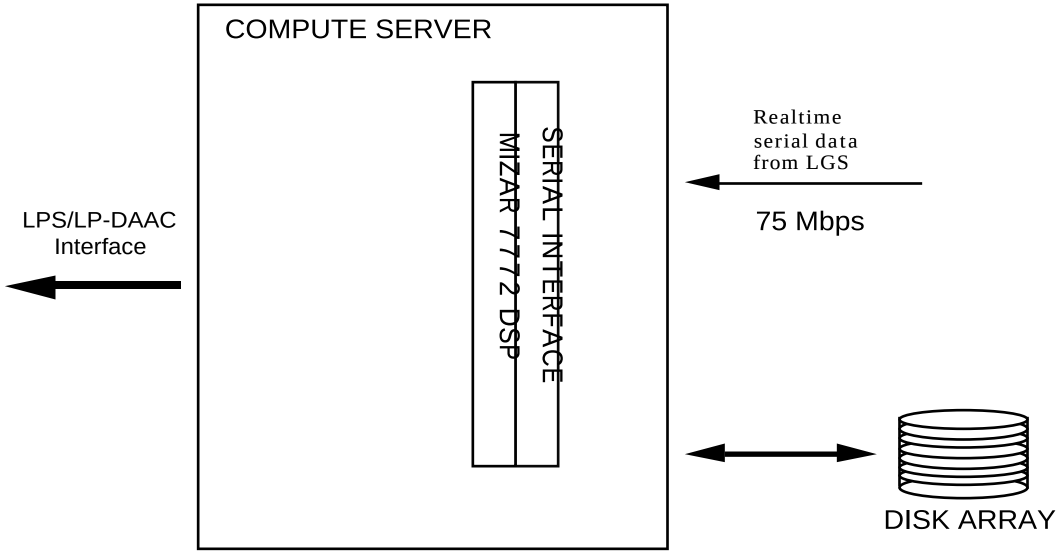
Front End Trade Study (cont.)

OPTION 6 - LPS SELECTED ARCHITECTURE



• This option contains two boards mounted in the compute server's VME chassis. A custom serial-to-parallel board converts the real-timedata to parallel for transfer to a COTS DSP board from MIZAR Inc. The DSP board provides the necessary buffering and a communication path across the VME.

• The received data is transferred to the data capture disk array, in real time, for subsequent storage, processing, and data dissemination.

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Front End Trade Study (cont.)

Advantages

OPTION 1 - HARDWARE REUSE
• Proven Technology
• Technical staff familiar with design

OPTION 2 - ASIC HARDWARE (< 20 Mbit/sec)
• Faster then Option 1.
• Proven Technology

OPTION 3 - ASIC HARDWARE (<150 Mbit/sec)
• Real-timeCCSDS processing

OPTION 4 - MODIFIED HIGH DENSITY TAPE INTERFACE
OPTION 5 - HIGH DENSITY TAPE SUBSYSTEM
• Commercial off the shelf solution

OPTION 6 - LPS SELECTED ARCHITECTURE
• Easily expanded and duplicated
• Cheapest Hardware Solution
• Lowest Maintenance costs.

Disadvantages

OPTION 1 - HARDWARE REUSE
• Expensive due to ID1 usage
• Necessitates dedicated Custom Hardware
• NRE Costs for BCH

OPTION 2 - ASIC HARDWARE (< 20 Mbit/sec)
• Expensive due to ID1 usage
• Necessitates dedicated Custom Hardware
• NRE Costs for BCH

OPTION 3 - ASIC HARDWARE (<150 Mbit/sec)
• Expensive due to ID1 usage
• Necessitatesdedicated Custom Hardware
• NRE Costs for BCH

OPTION 4 - MODIFIED HIGH DENSITY TAPE INTERFACE
OPTION 5 - HIGH DENSITY TAPE SUBSYSTEM
• Vendors were reluctant to unbundle components
• EDAC controller board must be modified
• The designs are proprietary

OPTION 6 - LPS SELECTED ARCHITECTURE
• CCSDS processing is performed post contact

Selection: Option 6, LPS BASELINE ARCHITECTURE

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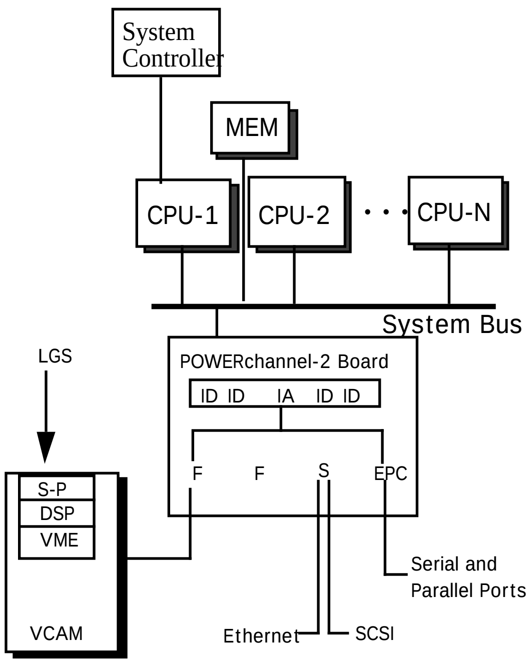
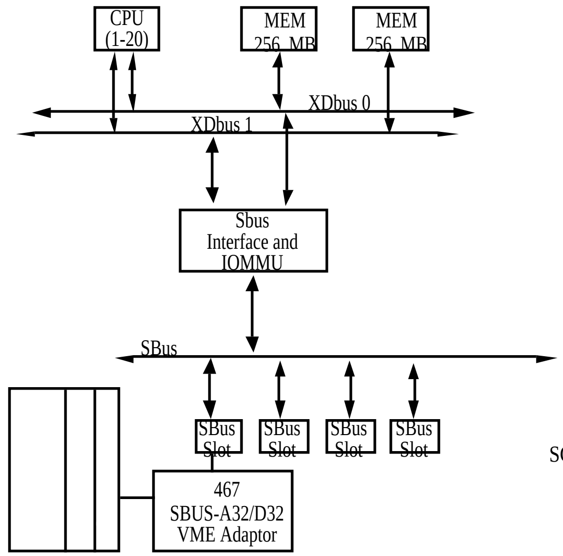
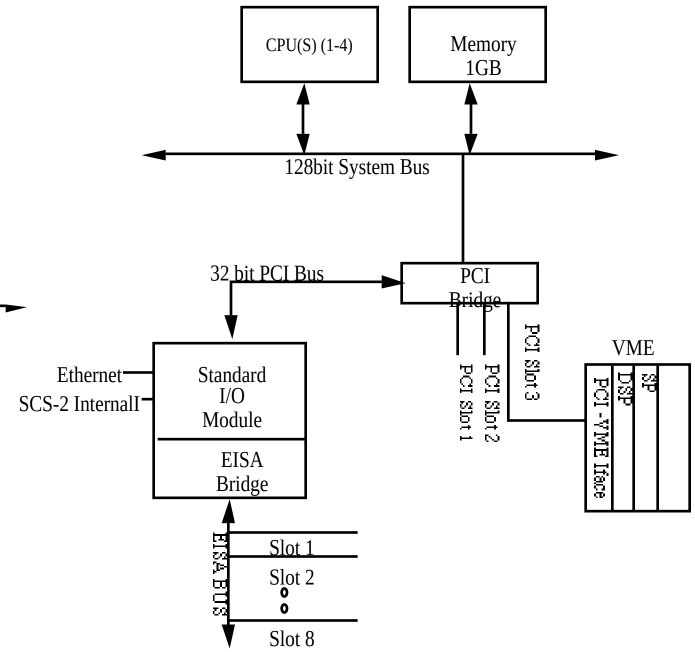
Compute Processor Trade Study



• Option 1 - SGI Challenge L or XL Servers



• Option 2 - Sun SPARCcenter 2000



• Option 3- DEC Alpha Server 2100 4/200

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Compute Processor Trade Study (cont.)

Advantages	Disadvantages
Option 1 SGI Challenge L or XL Servers	Option 1 SGI Challenge L or XL Servers
• Favorable Prototype results • Favorable Price/Performance ratio • Processor expandable to 12 or 36 • EDC familiar	• Development Staff not familiar w/ SGI
Option 2 - Sun SPARCcenter 2000	Option 2 - Sun SPARCcenter 2000
• Used in PACOR (staff familiarity)	• Unfavorable Prototype results • Unfavorable Price/Performance Ratio
Option 3- DEC Alpha Server 2100 4/200	Option 3- DEC Alpha Server 2100 4/200
• Favorable Prototype results • Favorable Price/Performance ratio	• Technical information not available • Processor expandability limited to 4

Selection: Option 1, The SGI Challenge L or XL

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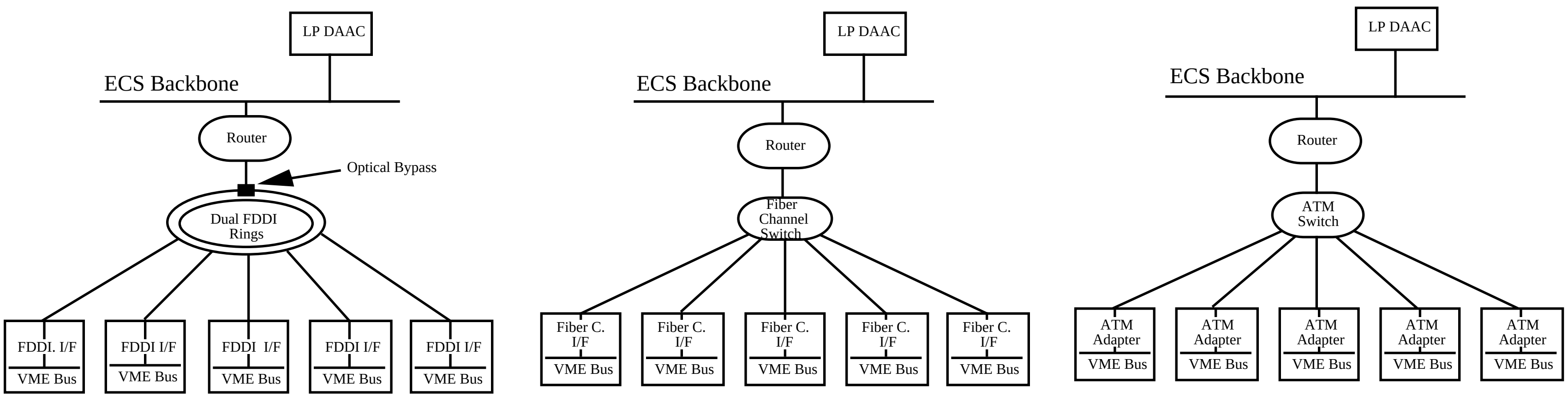
Back-End Trade Study

- Network Option 1.- Fiber Distributed Data Interface (FDDI)
- Network Option 2.- Fiber Channel.
- Network Option 3.- Asynchronous Transfer Mode (ATM).



Option 1 Option 2 Option 3

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Back-End Trade Study (cont.)

Advantages

Option 1.- Fiber Distributed Data Interface (FDDI)
- Dual Rings offer reliability
- Compatible with EDC
- Transfer rates of 20-100Mbps
- Supported by both SGI and third party vendors

Option 2.- Fiber Channel.
- Third party support available
- 1Gbps w/ simultaneous transmission.

Option 3.- Asynchronous Transfer Mode (ATM).
- Very Fast (155-622 Mbps)

Disadvantages

Option 1.- Fiber Distributed Data Interface (FDDI)
- Only one node can transmit at any one time
- Network can be saturated

Option 2.- Fiber Channel.
- Not used by EDC

Option 3.- Asynchronous Transfer Mode (ATM).
- Not supported by SGI
- No standards available
- Technology just emerging

Selection: Option 1, Fiber Distributed Data Interface (FDDI)

The LPS Architecture

- LPS Functional Block Diagrams
- LPS System Sizing Analysis
- LPS RMA Results
- Prototype results
- Level 0 DFD

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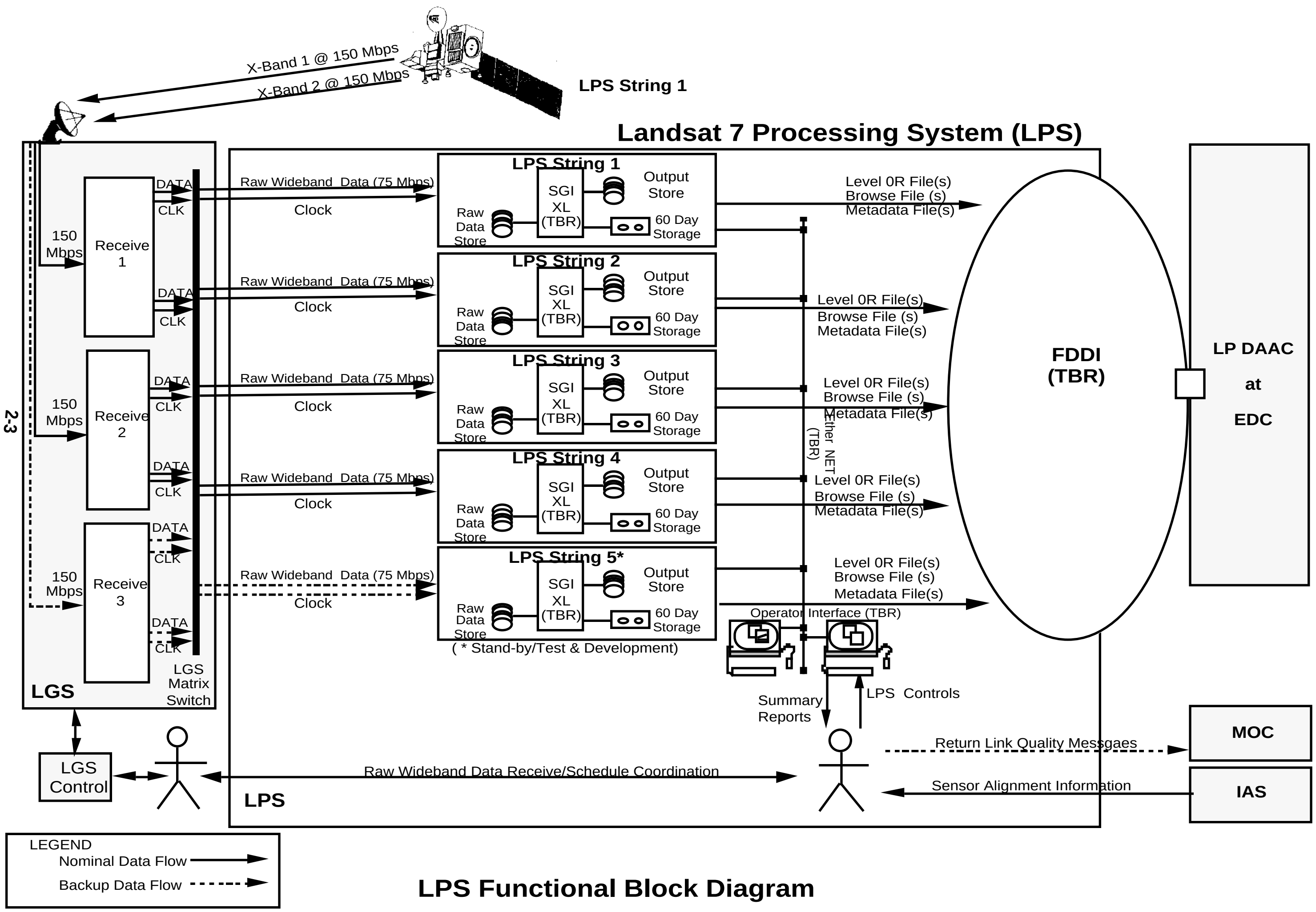
The LPS Architecture (cont.)



LPS Functional Block Diagram

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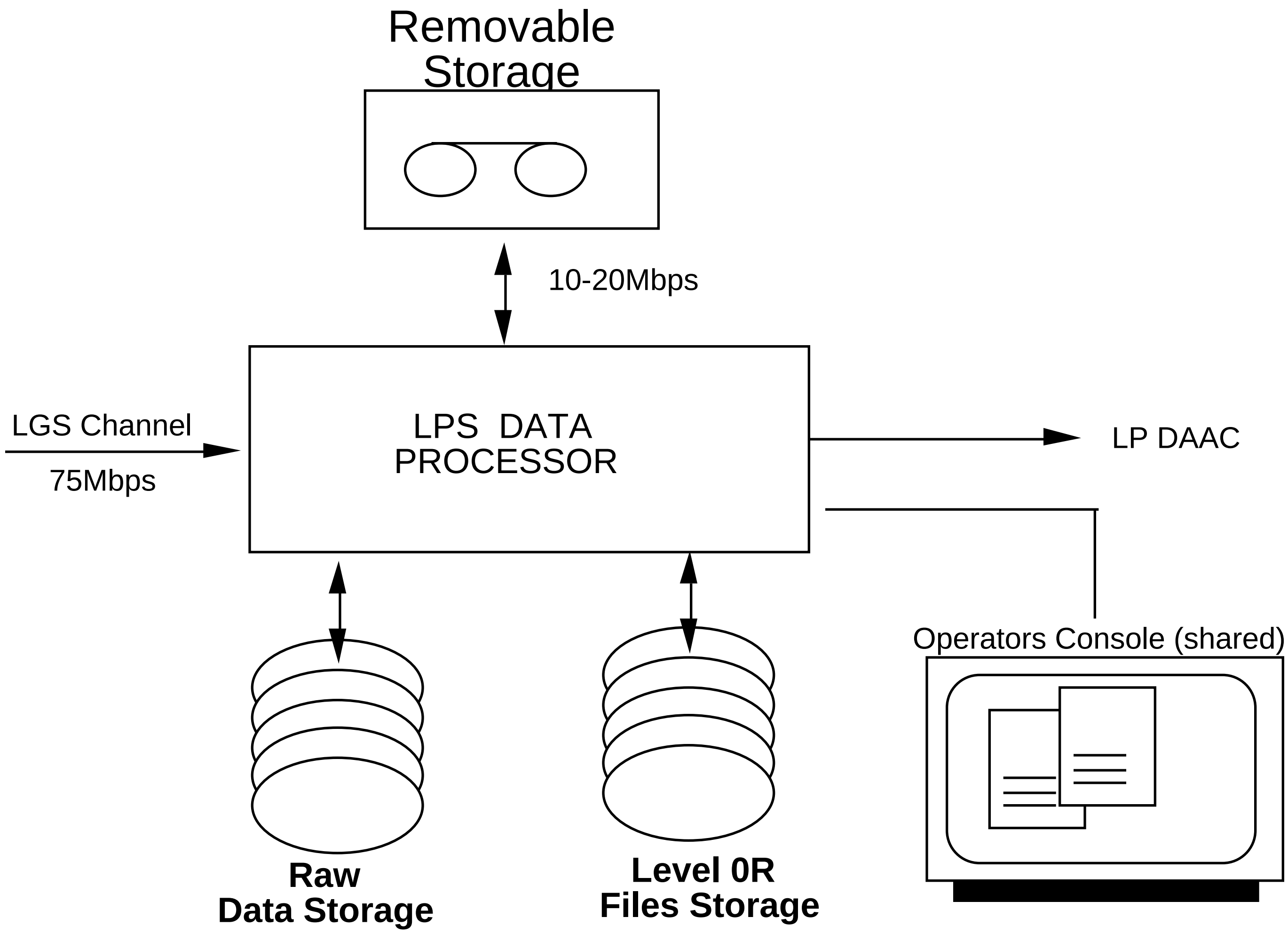
The LPS Architecture (cont.)



LPS Block Diagram

The LPS Architecture (cont.)

LPS System Sizing Analysis -One LPS String

• Raw Data Storage	19.125GB (per three contacts)
• 60-day Storage Media:	6.4 GB (per contact period)
• Output File Storage:	17.7 GB (per three contacts)
• Output Data Transfer Rate:	10 Mbps
• Processor Size:	806 MIPS
• Processors	6
• Main Memory:	675 MB
• System Bus Load:	95 MBPS

The LPS Architecture (cont.)

LPS RMA Results

- RMA Analysis - Assumptions
  - Total 5 LPS strings; 4 are used in operations
  - SGI Challenge L with embedded VME and COTS and make HW
  - Orbit Period: 99 minutes
  - Contact Period: 14 minutes
  - String switch over Time: 55 minutes
  - RMA Calculated Over 10,000 Hours

- RMA Analysis - (Five Strings)

- Number of LPS downtimes:	22.85
- Average Downtime:	20.94 Hours
- System Availability (Ao):	0.997
- MTTRes:	55 Minutes

- RMA Analysis - (One String)

- System Availability (Ao):	0.998
- MTTRes	165 Minutes

- RMA Analysis - (Four Strings)

- System Availability (Ao):	0.993
- MTTRes	165 Minutes

The LPS Architecture (cont.)

Prototypes Status and Results

- Raw Data Capture
  - **Objective**: Capture raw ETM+ wide band data to disk
  - **Status**: 90% Complete (in progress)
  - **Results**: Currently capturing data at 75Mbps

- CCSDS Processing
  - **Objective**: Perform CCSDS Grade 3 Processing in software (i.e. Frame Sync. Reed Solomon, CRC, and PN decode)
  - **Status**: 80% Complete
  - **Results**: Currently processing simulateddata at 23Mbps

- BCH Error Detection and Correction
  - **Objective**: Implement and benchmark BCH decoding and correction algorithms on the data pointer and mission data
  - **Status**: Complete
  - **Results**: Currently processing good data at 15Mbps

The LPS Architecture (cont.)

Prototypes Status and Results (cont.)

- Band Deinterleave
  - **Objective**: Benchmark the de-interleaving of band data in science data minor frames
  - **Status:** Complete
  - **Results:** Performance: 18Mbps
- ETM+ major Frame Synchronization
  - **Objective**: Process the Major frame using mission data w/o moving the VCDUs in memory, stream line efficiency, and benchmark performance.
  - **Status**: Complete
  - **Results**: Performance: 300+MBps
- Cloud Cover Assessment
  - **Objective**: Benchmark and evaluate the reuse of Cloud Cover algorithms
  - **Status**: Complete
  - **Results**: Subsampling 1 out of 4 pixels and 1 out of 4 lines assesses 1 scene in 20 seconds. Reuse of existing Cloud Cover algorithms not desirable due to inaccurate assessments.

Prototypes Status and Results (cont.)

- Browse Generation
  - **Objective**: Benchmark Wavelet and Subsampling methods of creating browse files such that the results will display in a 1024x1024 display maximize image quality.
  - **Status:** Complete
  - **Results:**

Wavelet	Subsampling	Initial File Size	Browse Files Size	Time (seconds)
2	2	41MB	.65MB	22
1	4	41MB	.65MB	14

MO&DS DIRECTORATE

CODE 500

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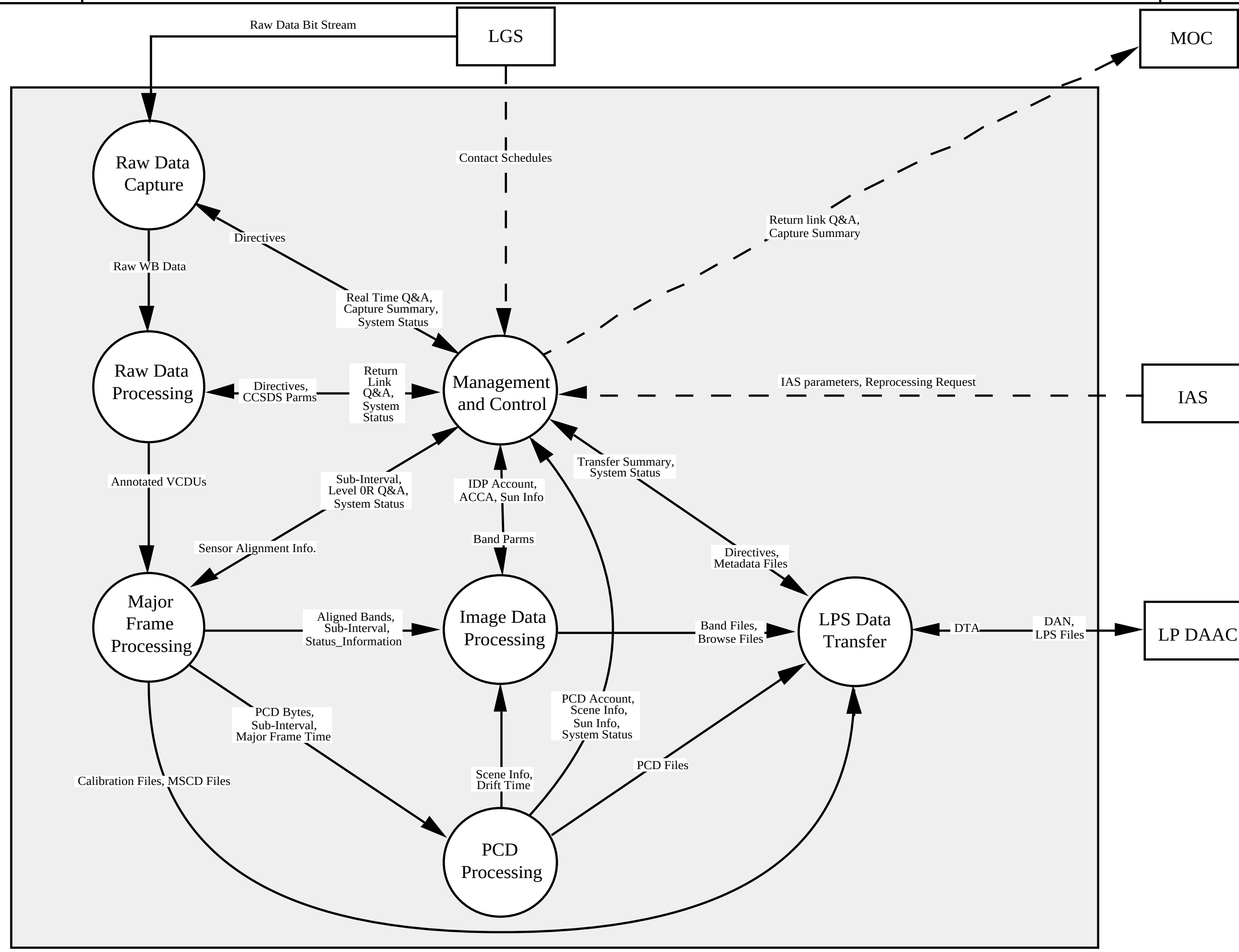
Level 0 DFD and System Element Functions



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System Element Functions

- Raw Data Capture Subsystem (RDCS)
  - Receive and record raw wideband data from LGS
  - Restage raw wideband data
  - Generate raw data capture summary
- Raw Data Processing Subsystem (RDPS)
  - Perform CCSDS Grade 3 Service
  - Perform BCH Error Detection and Correction
  - Generate and report return link quality and accounting
- Major Frame Processing Subsystem (MFPS)
  - Process ETM+ major frames
  - Extract Payload Correction Data bytes and status information
  - Generate Mirror Scan Correction Data files and Calibration files
  - Determine Subintervals
  - Deinterleave/Reverse bands
  - Align Bands

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System Element Functions (cont.)

- Payload Correction Data Processing Subsystem (PCDS)
  - Extract clock drift rate information
  - Extract calibration door activity status
  - Determine scene identification
  - Produce PCD file
  - Produce PCD accounting information
- Image Data Processing Subsystem (IDPS)
  - Generate Browse Files
  - Generate Band Files
  - Produce Automatic Cloud Cover Assessment
  - Produce browse, band and cloud cover accounting information
- Management and Control Subsystem (MACS)
  - Control and monitor LPS devices and processes
  - Provide interface between operator and LPS
  - Generate LPS metadata file

System Element Functions (cont.)

- LPS Data Transfer Subsystem (LDTS)
  - Coordinate LPS file transfer to the LP DAAC
  - Provide network and communication support
  - Support LPS file transmission to the LP DAAC
  - Manage LPS output data store
  - Provide transfer summary information

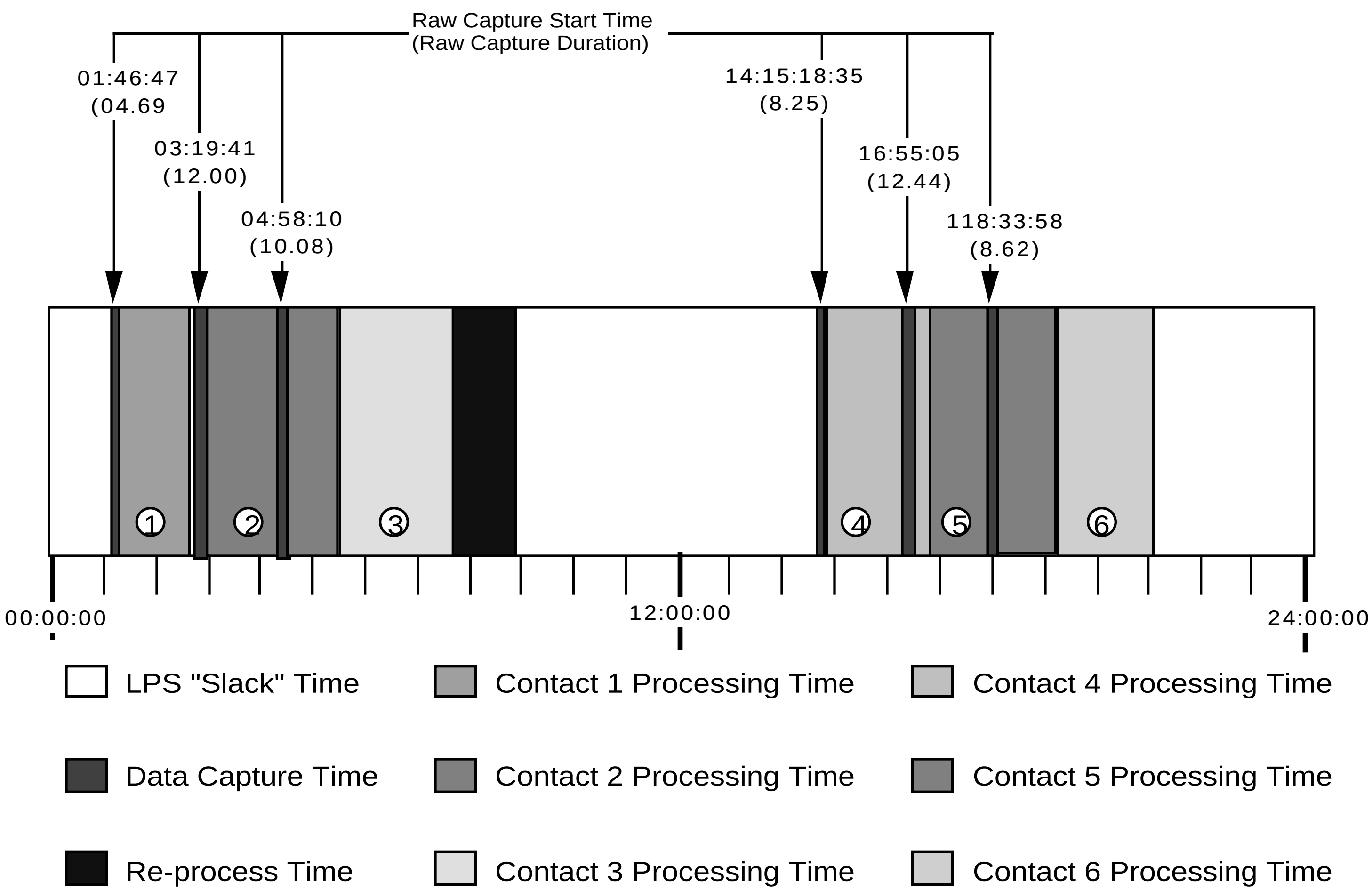
Operational Scenarios

- LPS Setup
- Receive Data From LGS
- Process Data to Level 0R
- Transfer Files to LP DAAC
- System Maintenance, Training, and Testing
- Contingency Operations
- SIT Action Item: Data “Catch-Up”

Landsat 7 Processing System SDR/SSR

Operational Scenarios (cont.)

LPS Operational Cycle - 24 Hours



Operational Scenarios (cont.)

LPS Receive

- Sensor alignment parameters from IAS
- Contact schedules from LGS

LPS Setup (per string)

- Configure LPS strings to LGS output channels
- Configure LPS strings to LP DAAC communication interfaces
- Startup LPS; bring up user interface
- Enter/update LPS parameters
- Set LPS thresholds
- Set up system monitoring
- Receive and process test data set

Operational Scenarios (cont.)

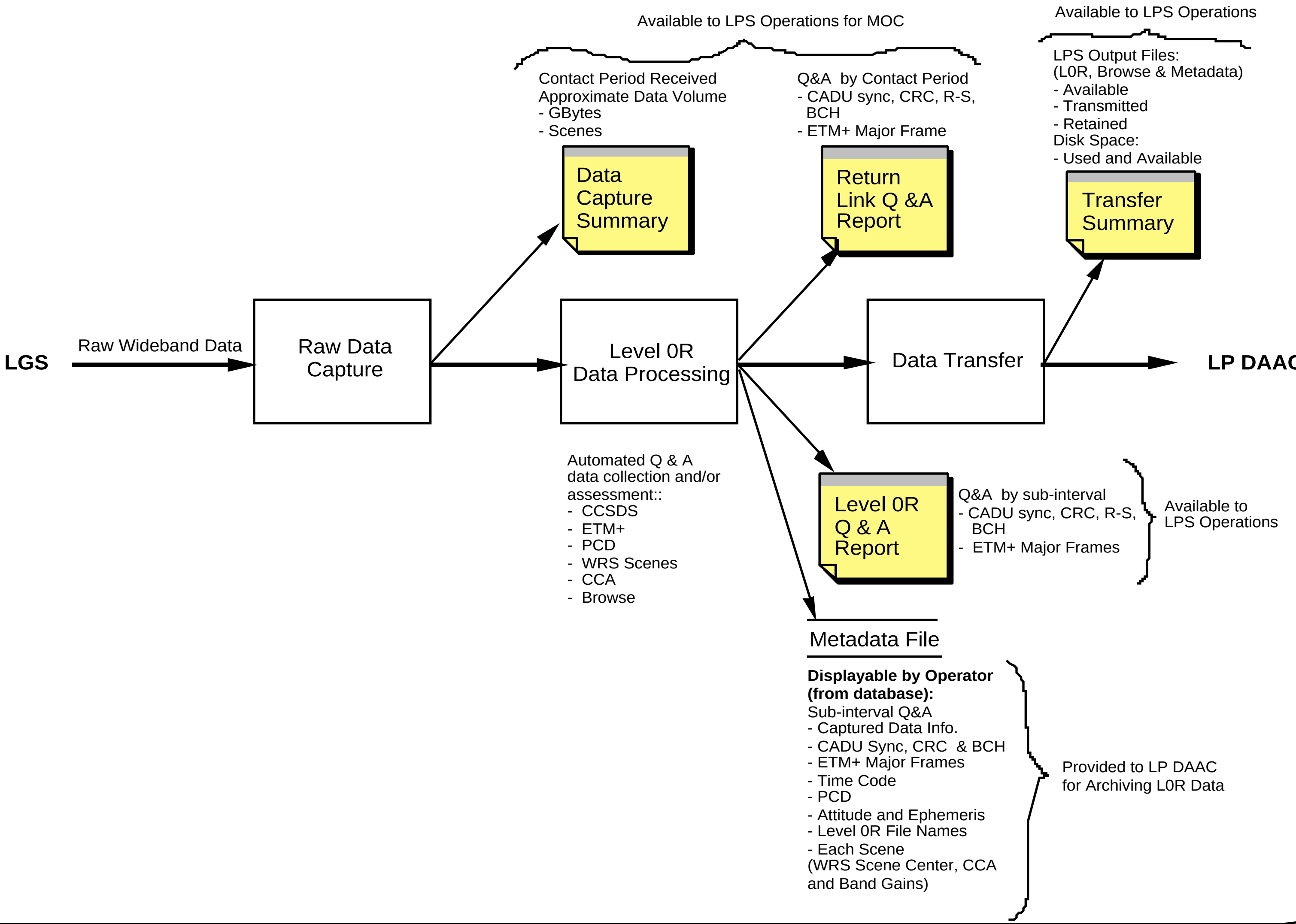
LPS Receive Data From LGS (per string)

- Review contact schedule for data capture times
- Enable data capture to disk
- Verify Acquisition of Signal with LGS operator
- Monitor data receipt process
- Verify Loss of Signal with LGS operator
- Disable data capture to disk
- Print and review Data Receipt Summary Report
- Provide MOC with Data Receipt Summary
- Mount tape on drive
- Start copy to tape
- Stop copy to tape
- Label and move tape to 60-day storage

Landsat 7 Processing System SDR/SSR

Operational Scenarios (cont.)

LPS Data Qulaity and Accounting Overview



Operational Scenarios (cont.)

Process Data to Level 0R (per string)

- Start processing for selected contact
- Monitor data processing function
- Print and review Return Link Quality & Accounting Report
- Print and review Level 0R Quality & Accounting Reports
- Verify data are stored for LP DAAC retrieval

Operational Scenarios (cont.)

Transfer Files to LP DAAC (per string)

- Monitor interface with LP DAAC
- Verify Data Availability Notice (DAN) sent to LP DAAC
- Verify successful transfer of files
- Print and review Data Transfer Summary Report
- Monitor deletion of successfully transferred files

Operational Scenarios (cont.)

Reprocess LPS Data

- Operator receives reprocessing request from IAS
- Schedule data reprocessing time
- Verify requested data is available in 60-day storage
- Schedule data reprocessing time
- Physically locate and mount tapes on drives (each string)
- Restage data to be processed (each string)
- Proceed with “Process data to Level 0R” and “Transfer files to LP DAAC “ procedures
- Return tapes to physical storage

Operational Scenarios (cont.)

System Maintenance, Training, and Testing

- A system scheduled for maintenance can be:
  - rotated out of real-time operations
  - accessed during slack time opportunities
- The spare string can be used for training in real time
- Testing of a newly upgraded/modified system can be performed in real time, parallel to an operational system for absolute verification

Operational Scenarios (cont.)

Contingency Operations

- LGS-to-LPS interface problems
  - prior to a contact
  - during data receipt
- LPS-to-LP DAAC interface problems
  - prior to data transfer
  - during data transfer operations
  - LPS output storage capacity
- Hardware failures
  - tape drive
  - data storage disks
- LPS string problems
  - data receipt/store
  - data processing
  - data transfer
  - file deletion

Agenda

- Introduction
- System Design
- Software Specification
    - Approach
    - Software Requirement Specification
    - Software Sizing Estimates
- Conclusion